Space Weather Technical Forecast

Issued on Sunday, 03 September 2023 at 01:27 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: G1-G2 Moderate storms expected 03 Sep due CME arrivals and ongoing fast winds. Decreasing risk of M-flares.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate with a long duration M3.3 flare from AR3413, peaking at 02/0712UTC. This region is now on the northwest limb, but soon moving onto the far-side. While currently impossible to analyse, magnetic looping is visible above the region in SDO imagery. The other four sunspot regions on the disc remain small and simple, and either stable or showing signs of decay.

The CME associated with the M3.3 flare of AR3413 is missing Earth. A further filament eruption was observed from the northwest disc in SDO imagery around 02/1754 UTC. No CME has yet been identified from this eruption with the available imagery.

Solar Wind / Geomagnetic Activity: Ongoing CH40/+ fast wind was further enhanced by an apparent transient enhancement from 02/0344 UTC. This may have been an early but also only glancing arrival of the CME from the filament eruption on the 30 Aug, however this remains uncertain. Solar winds observed by ACE at L1 were generally elevated at 550-600km/s, but increased to be strong at 650-750km/s between 02/0344 UTC and 02/1330 UTC. Density was largely below average until 02/1330UTC, then increased to be above average, peaking near 30pppc by 02/2300 UTC. Total Interplanetary Magnetic Field (IMF), Bt, was Weak at first, but increased to Moderate for a time after 02/0344 UTC. Overall this ranged 5-10nT, with the north-south direction, Bz, predominately negative (southward) ranging between 5 nT and -9nT. Phi angle was positive (away from the Sun) at first, then variable 02/0344-1330 UTC, before becoming positive again. Phi then became negative (towards the Sun) from 02/2000 UTC. Geomagnetic activity was initially Unsettled but became Active to G1 Minor Storm (Kp4-5) from 02/0300 UTC.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux declined from slightly elevated but below S1 Minor Radiation storm (around 6pfu) to near background, as the effects of the 01 Sep S1 event eased. GOES16 high energy (greater than 2MeV) electron flux was mainly at background, but briefly Moderate peaking 320 pfu at 02/1905 UTC. The associated 24-hour fluence was well below the Active threshold, with 4.16e6 integrated pfu observed at 02/2100 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: A chance of Moderate activity day 1 (03 Sep), with a further risk of M-flares from AR3413, but then easing to mainly Low activity as this rotates further onto the far-side, with the other spots on the disc currently smaller and simpler.

Solar Wind / Geomagnetic Activity: There are CMEs in the forecast. The first was expected to arrive 02/2200 UTC +/- 9hours and is from the filament eruption on 30 Sep, but may have already passed as the source of the transient enhancement 02/0300 UTC. The second is expected to arrive 03/0600 +/- 9hours, and is from the moderately fast CME which occurred alongside the M-flare of AR3413 on 01 Sep. Ongoing CME influence is then likely into day 2,

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before easing. However winds are likely to remain elevated due to the fast winds of CH40/+ and CH42/+. Geomagnetic activity is expected to be Active with a chance of G1 Minor storm intervals expected at first day 1 (03 Sep), but with a chance of rising to give a spell G1-G2 Moderate storms, with any CME arrivals, and a slight chance of an isolated G3 Strong Storm interval. Conditions easing day 2 (04 Sep) onward to mainly Quiet to Unsettled with Active intervals, and a decreasing chance of G1 Minor Storm intervals.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux is expected to continue declining towards background levels, with only a slight chance of further enhancements on day 1 (03 Sep), and a much reduced risk thereafter. High energy (greater than 2 MeV) electron flux is expected to be suppressed at first due to the CME arrivals, before potentially rising as solar wind pressure eases later day 2 and day 3. There is a chance of Moderate to High flux by then end of day 2 (04 Sep), but more likely day 3-4 (05-06 Sep). The associated 24 hour fluence is expected to remain below the Active level (1e8 integrated pfu) at first, but with an increasing chance of rising above by day 3 (04 Sep).

Figure 1a. L1 Solar Winds (from ACE)

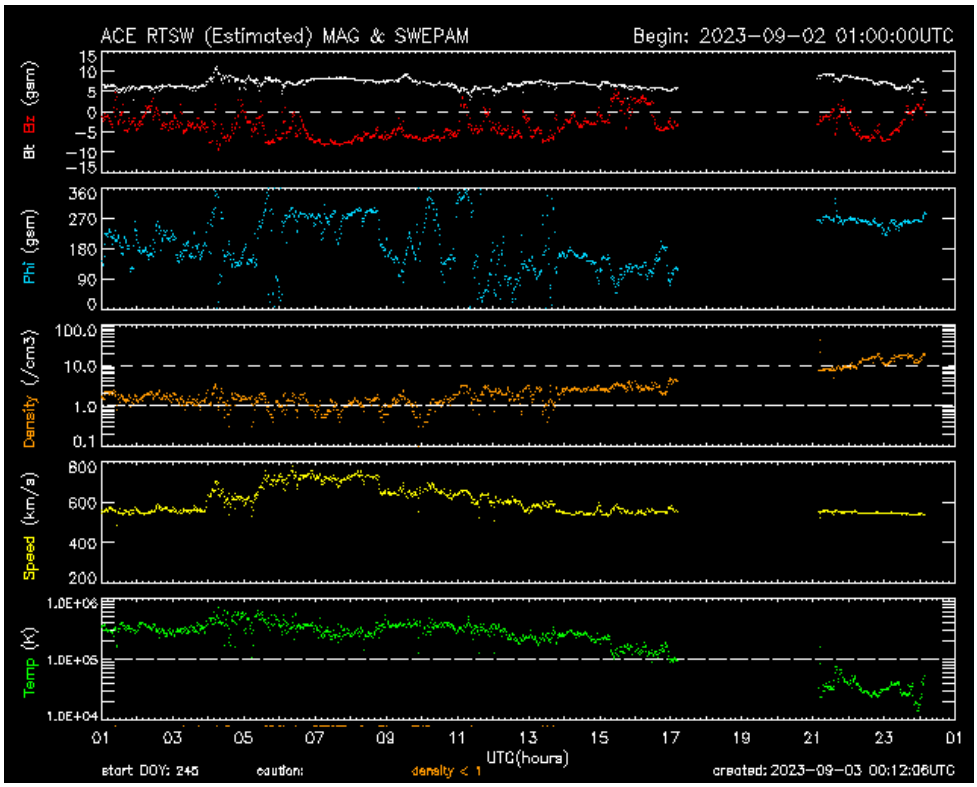

Figure 1b: BGS current estimated observed Kp

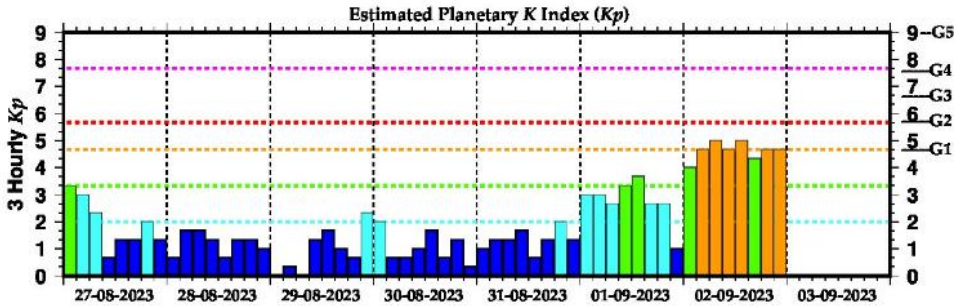

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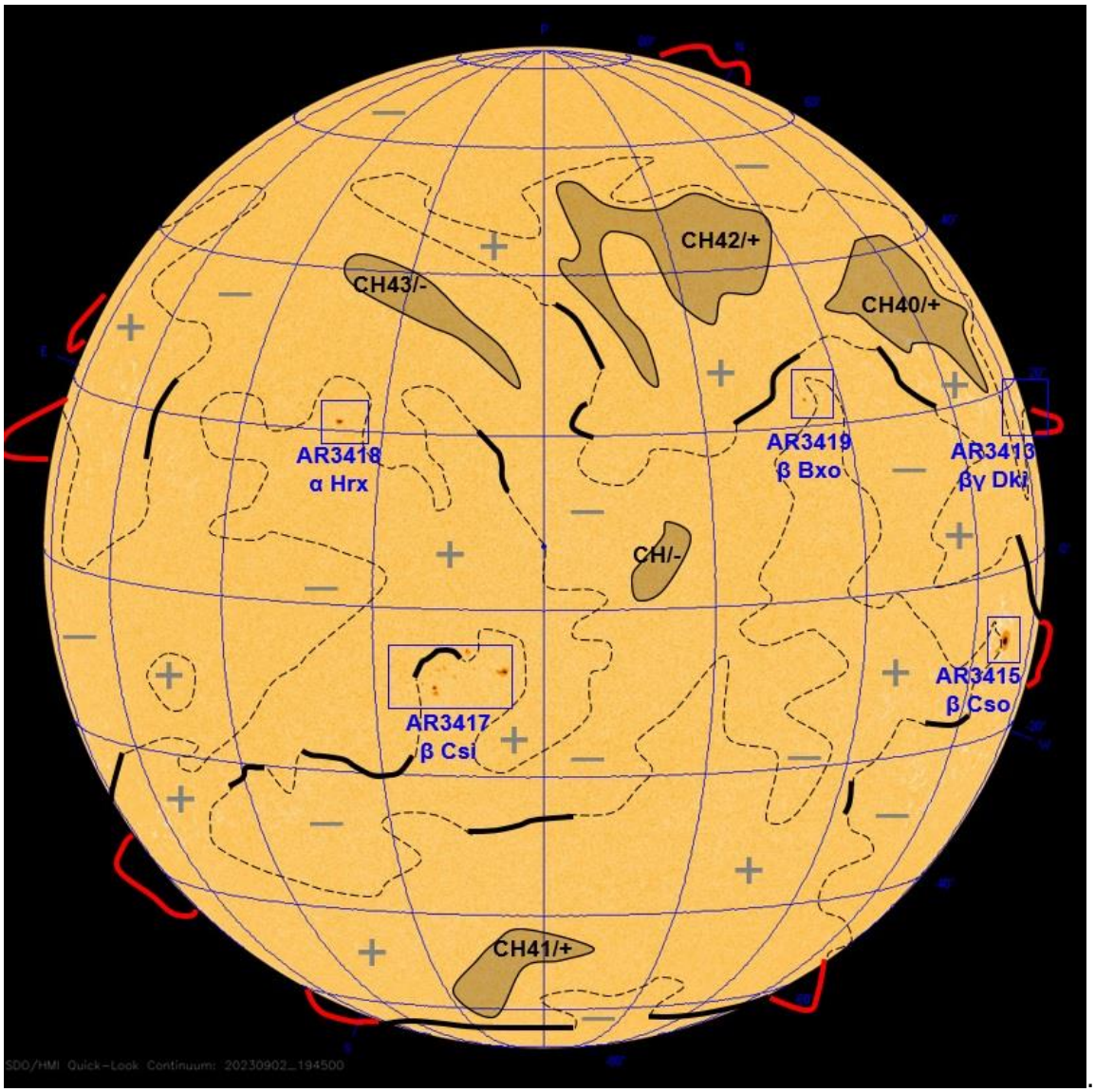
Figure 1b. Solar Analysis Valid 02/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are two CME arrivals featured in this forecast. The first is from a filament eruption on 30/2000 UTC, and was forecast to arrive 02/2200 UTC +/- 9hrs. However it is possible that this has already arrived early, but largely missing. This would then be the cause of a weak transient seen in the solar wind 02/0344-1330 UTC. However, it is still possible that this first CME is yet to arrive early on day 1 (03 Sep). A filament eruption observed in the northwest disc around 02/1750 UTC has is currently awaiting coronagraph imagery to assess any likely CME or Earth-directed component.

The second CME arrival forecast is associated with the M-flare of AR3413 which peaked 01/0352 UTC. This is currently anticipated to give a more glancing arrival also day 1, 02/0600 UTC +/- 9 hours but will likely give a further enhancement to geomagnetic conditions through the day. This may then combine with the previous arrival to give a more significant geomagnetic disturbance. Ongoing effects are then possible into day 2 (04 Sep).

Otherwise, background winds are currently elevated to strong, due to the influence of the fast wind from CH40/+. This is expected to be followed by the fast wind from CH42/+ during day 2 and into day 3, leading to elevated solar winds remaining likely throughout, perhaps easing day 4.

Overall Active conditions expected with a chance of G1 Minor storm intervals expected at first day 1 (03 Sep), but with a chance of rising to give a spell G1-G2 Moderate storms with any CME arrivals, and a slight chance of an isolated G3 Strong Storm interval. Conditions easing day 2 (04 Sep) onward to mainly Quiet to Unsettled with Active intervals, and a decreasing chance of G1 Minor Storm intervals.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	70	30	10	10
Strong	G3	No	20	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
31/0305 UTC	Partial	Filament	NW, but CME directed S	610	02/2200 +/- 9hrs	Possibly already arrived.
01/0625	Partial	M1.2 AR313	NW	1125	03/0600 +/- 9hrs	Glancing impact

Figure 2a: Enlil showing expected arrival

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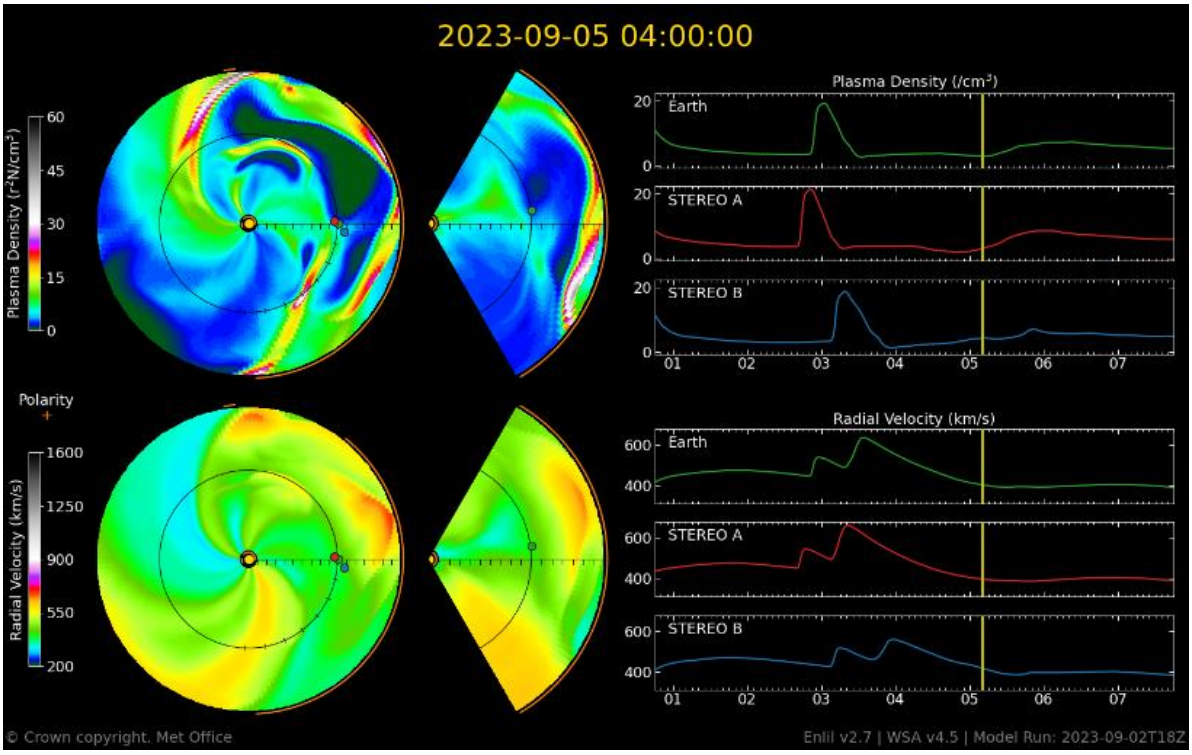
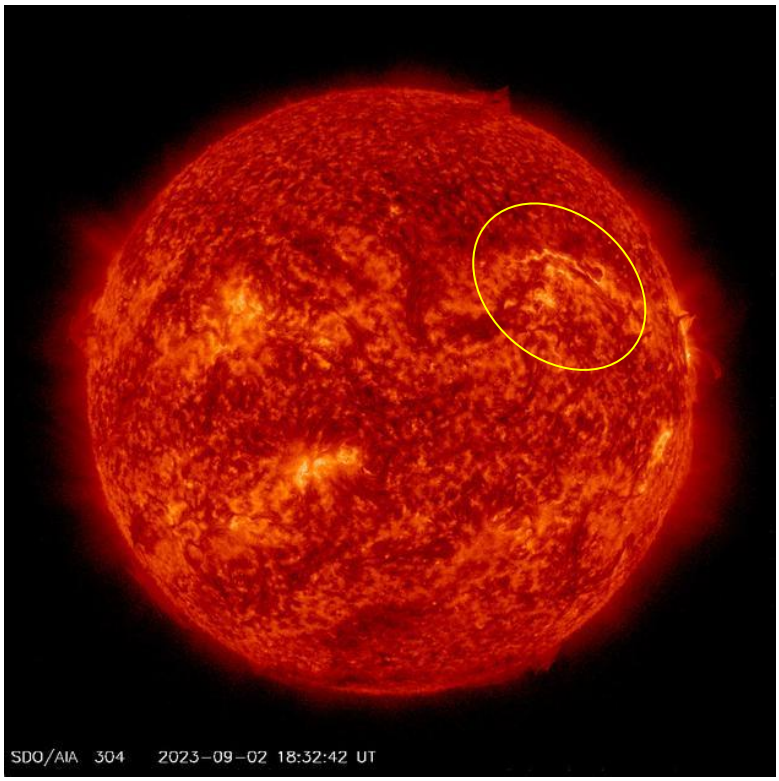


Figure 2b: SDO aia-304 showing filament eruption, with two ribbon effect visible (circled). CME not yet observed in available imagery.



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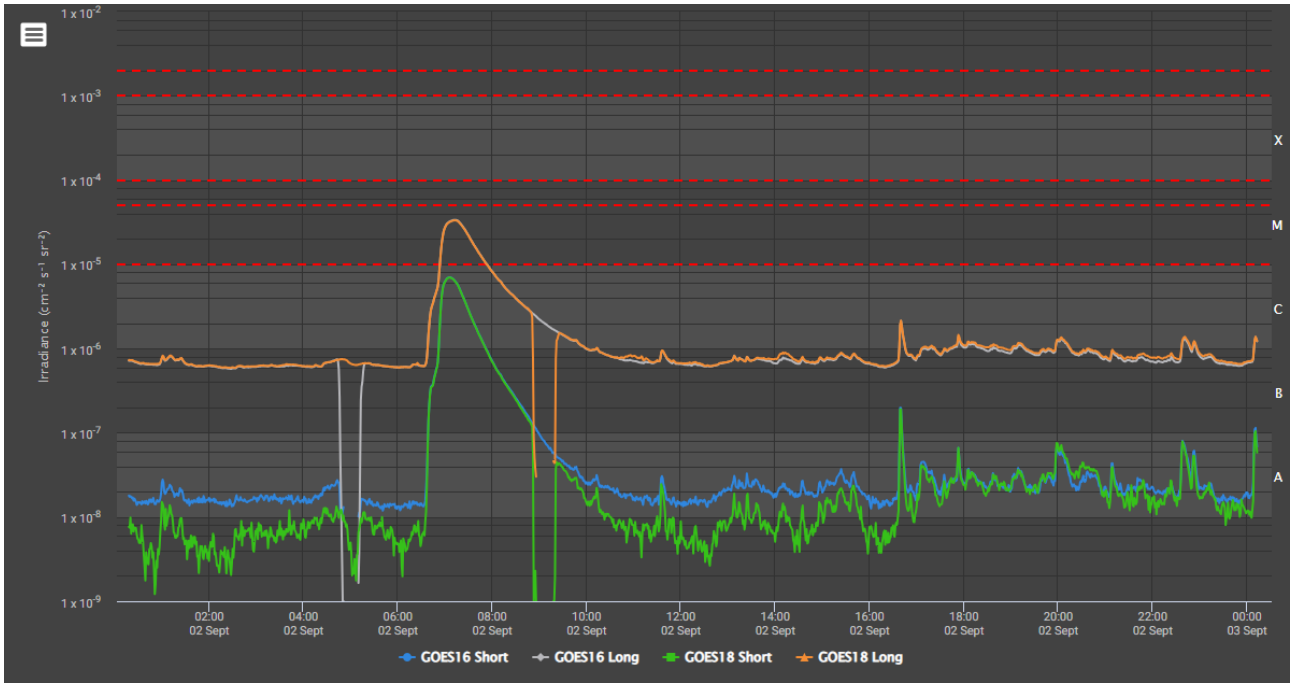
Radio Blackouts - X-Ray Flares:

Activity is Moderate, but expected to ease to be mainly Low as AR3413, which is now on the northwest limb, continues to move onto the far-side. This region has been the source of any recent significant activity, including a couple of M-flares in the last 24 hours, and with its magnetic canopy remaining visible above the limb will continue to provide a chance of similar activity on day 1 (03 Sep). This risk receding by day 2 (04 Sep).

The other regions four regions currently on the disc are smaller and simpler, and either stable or showing sign of decay. Activity is expected to ease to be mainly Low day 2 onward, unless any further development or sunspot emergence occurs.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	50	20	20	30
Very Active	R3 to R5 X Class	No	5	1	1	1

Figure 3: GOES-16/18 X-ray Flux



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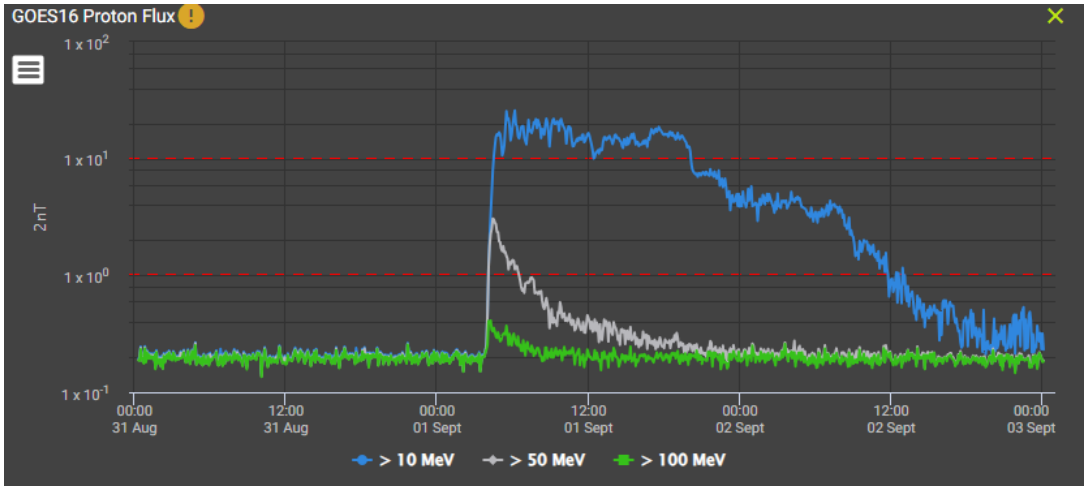
Solar Radiation Storms - (High Energy Protons):
The high energy (greater than 10MeV) proton flux observed by GOES-16 has now largely eased to background after the S1 enhancement on 01 Sep. There remains a slight chance of further increases day 1, given any large flares AR3413 from over the northwest limb. This risk then recedes day 2 onward with this sunspot moving further onto the far-side and the other regions on the disc currently smaller and simpler.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	5	2	2
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

Figure 4: Last 3 days GOES-16 Proton Flux



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High Energy Electrons Event (≥ 2MeV):
High energy (greater than 2 MeV) electron flux observed by GOES16 is currently at Background to Moderate. Any CME arrival likely to increase electron populations throughout the Van Allen belts, but initially compressing them into lower orbits. As the solar wind pressure eases, mainly day 2 onward (04 Sep), flux will see an increasing chance of becoming Moderate to High.

There is low confidence in this forecast, however as it is very dependent upon the strength of the anticipated CME arrival(s) day 1 (03 Aug). Any further coronal hole fast wind interactions later day 2 (04 Sep) onward could also lead to periods of drop out, along with subsequent enhancements, however this detail currently remains very uncertain.

The associated 24 hour fluence is expected be below the Active (1e8 integrated pfu) threshold day 1 (03 Sep), but with an increasing risk of rising above day 2 (04 Sep). MOSWOC REFM is likely to be poor, increasing fluence too quickly, as this doesn't take account of the forecast CME arrival(s).

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	10	40	60	60
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: GOES-16 Electron Flux and Fluence with REFM and recurrence

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